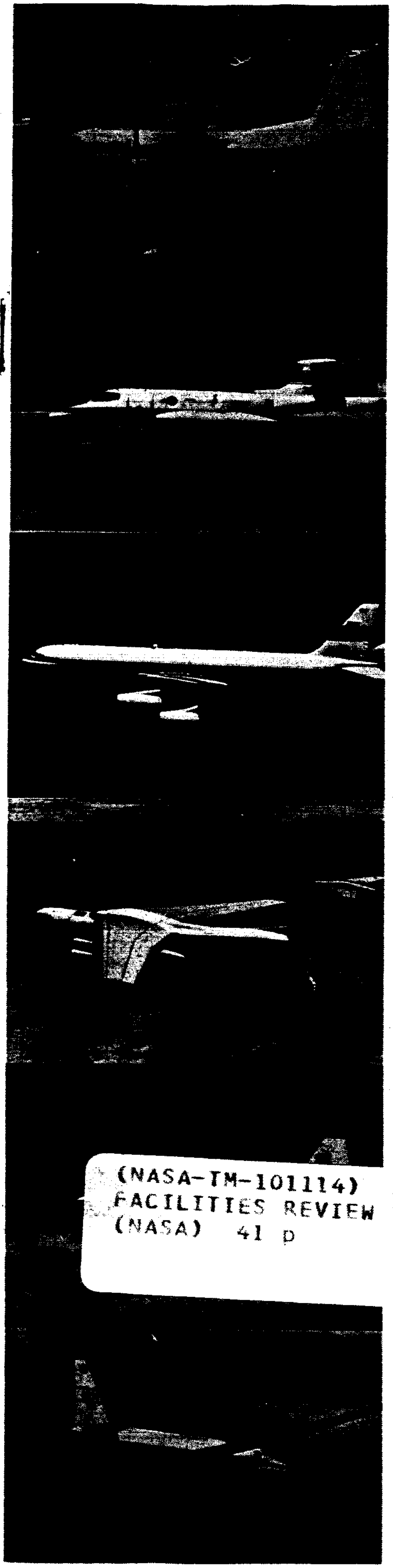

Report of the

NASA AIRBORNE OBSERVATORY FACILITIES

Review Team

II - Final Report

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NASA AIRBORNE OBSERVATORY FACILITIES REVIEW TEAM

February 1978

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James J. Ward, LeRC 6210/Chief, System Branch	Executive Secretary

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NASA AIPBORNE OBSERVATIONAL FACILITIES REVIEW TEAM

CHAIRMAN	- DANIEL J. SHRAMO, LEWIS RESEARCH CENTER DIRECTOR, SPACE SYSTEMS AND TECHNOLOGY
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ADVISOR	- WILLIAM E. RICE, JOHNSON SPACE CENTER ACTG. MGR., EARTH RESOURCES PROGRAM OFFICE
ADVISOR	- ROBERT W. SOMMER, NASA HEADQUARTERS DIRECTOR, NASA AIRCRAFT OFFICE

INTRODUCTION

In the Special Announcement from Dr. A. M. Lovelace, dated September 7, 1977, dealing with NASA Civil Service Manpower Adjustments, a number of Agency issues were enumerated. It was indicated that special study teams would be formed to study, evaluate and make recommendations concerning these issues. One of the first issues addressed was the Airborne Applications Program which was subsequently expanded to include all of NASA's aircraft observational platforms. The charter for the observational aircraft review team was formulated. (See Enclosure 1). Daniel J. Shramo of Lewis Research Center was requested to chair the committee. The charter required that all aircraft used as observational platforms be examined and that all programs using these aircraft be reviewed. In FY 77, a total of 24 NASA aircraft were utilized as airborne observational platforms, and eight of the ten centers participated in the program to some degree. The charter of the review team can be summarized into the following four objectives:

1. Define current airborne observational facility capabilities.
2. Establish projected needs.
3. Recommend changes that will improve economy of operation and better match capability to projected needs.
4. Consider desirability of consolidating science and applications airborne facilities.

The preliminary schedule that was developed was a very vigorous and ambitious one as shown in figure 1. The team membership was chosen to reflect both a broad background and specific relevant experience such that all facets of the aircraft program could be studied. The team membership and their organizations are shown in figure 2.

METHODOLOGY

The methodology adopted for the review process is shown in figure 3. The methodology of information acquisition was chosen to be sure to acquire the information from all four organizational elements that are involved in the aircraft program; namely, Headquarters program offices, Headquarters aircraft office, the two field centers that operate the principal observational aircraft, and field centers that use observational aircraft. The Headquarters program offices (OA and OSS) were requested to provide a 3-year history and a 3-year projection of flight requirement program resources and a listing of all aircraft involved. The aircraft office

ENCLOSURE 1

REVIEW TEAM CHARTER

1. Title: NASA Airborne Observatory Facilities

2. Objective:

   To determine the desirability of consolidating science and Applications Airborne Facilities. Airborne Facilities are defined as all NASA aircraft and associated facilities and equipment that are utilized to support observation type activities, including ground truth, sensor development, ASVTs, and support of regional overflights for disaster assessment and other local problems. This study will examine the full range of current capabilities versus anticipated needs and recommended changes that will improve the economy of operation and better match capabilities to those projected needs.

3. Background:

   Aircraft support to the Science and Applications Program involves approximately 24 aircraft at eight NASA Centers, including JPL. The vast majority of this effort is centralized at JSC and ARC. At least one study has been conducted to assess the economy of operation if the airborne facilities were centralized at a single Center. The results of that study were not conclusive. Today, as we enter the Shuttle era, it is important that we reassess the role of airborne facilities and full range of capability this agency requires to meet future needs.

4. Schedule:

   A report of recommendations should be available in no more than 60 days and a status report is due in 30 days.

5. Considerations:

   a. The study should identify all aircraft involved in providing support to Science and Applications program.

b. Utilizing Center and program office inputs, a three to five year projection of capability versus needs should be made and the total operational costs estimated. It is up to the study to insure that the needs are reasonable and supported by previous experience.

c. Using the above projections, alternatives to achieve consolidation should be examined and recommended.

d. Specific funding, manpower, institutional and facility impacts for all recommendations are to be identified.

NASA AIRBORNE OBSERVATORY FACILITIES

PROGRAM REVIEW SCHEDULE

COMPLETE SELECTION OF TEAM MEMBERS	SEPTEMBER 23
INITIAL TEAM MEETING AT NASA HEADQUARTERS	SEPTEMBER 29
OA PROGRAM PRESENTATION TO TEAM	SEPTEMBER 30
OSS PROGRAM PRESENTATION TO TEAM	SEPTEMBER 30
PROGRAM REVIEWS OF WEST COAST CENTERS	WK OF OCT. 3
PROGRAM REVIEWS OF EAST COAST CENTERS	WK OF OCT. 11
TEAM REVIEW OF DATA AND INFORMATION	WK OF OCT. 17
ADDITIONAL DATA AND INFORMATION REQUEST AND DRAFT OF PRELIMINARY ASSESSMENT	WK OF OCT. 24
PRESENTATION OF STATUS REPORT	WK OF NOV. 7
PRELIMINARY DRAFT TO CENTER DIRECTORS AND APPROPRIATE HEADQUARTERS OFFICES	WK OF NO. 14
FINAL REPORT	WK OF DEC. 5

Figure 1

NASA AIRBORNE OBSERVATIONAL FACILITIES REVIEW TEAM

CHAIRMAN	- DANIEL J. SHRAMO, LERC 6000/DIRECTOR, SPACE SYSTEMS AND TECHNOLOGY
EXEC. SEC.	- JAMES J. WARD, LERC 6210/CHIEF, SYSTEMS BRANCH
MEMBER	- PAUL F. HOLLOWAY, LARC 6000/DIRECTOR FOR SPACE
MEMBER	- WILLIAM S. LOGAN, JR., NASA HQ. SA/MANAGER, SMALL EXPL./S. ROCKETS/ AIRBORNE/BALLOONS
MEMBER	- BERNARD T. NOLAN, NASA HQ. ERA/MANAGER, SPACELAB/SHUTTLE PROG. INT. OFFICE & AIRP
MEMBER	- GARY A. ZARLENGO, NASA HQ. BR/OFFICE OF DEPUTY CONTROLLER
ADVISOR	- MARTIN A. KNUTSON, ARC SE/CHIEF, AIRBORNE MISSIONS & APPLICATIONS DIVISION
ADVISOR	- WILLIAM E. RICE, JSC HA/ASST. MGR., EARTH RESOURCES PROGRAM OFFICE
ADVISOR	- ROBERT W. SOMMER, NASA HQ. YP/DIRECTOR, NASA AIRCRAFT OFFICE

Figure 2

METHODOLOGY

INFORMATION ACQUISITION

- O HEADQUARTERS PROGRAM OFFICE OVERVIEW
- O HEADQUARTERS AIRCRAFT OFFICE OVERVIEW
- O VISIT PRIMARY OBSERVATIONAL AIRCRAFT CENTERS
- O DETAILED PROJECT AND TASK REVIEWS BY USER CENTERS

INFORMATION ANALYSIS

- O STRUCTURED SUBTASK TEAMS TO ADDRESS
  - FUTURE REQUIREMENTS DEFINITION AND VALIDATION
  - CONSOLIDATION
  - POLICY ISSUES

PROVIDE CONCLUSIONS AND RECOMMENDATIONS

- O STATUS REVIEW
- O FINAL REPORT

Figure 3

provided an overview of the aircraft used to support the observational programs, a breakdown of the total flight hours and operational resources utilized. The flight history was also categorized as to flight hours uses; i.e., proficiency, data hour, ferry hour, etc., where this information was available.

The primary observational aircraft field centers, ARC and JSC, each were visited. The center reviews included:

- a general program overview
- a review of the management process and the organizational structure of the aircraft program at that center
- a detailed program review of each aircraft at that center
- a 3-year history and a 3-year projection of the program resources and aircraft operation hours
- a tour of the aircraft and support facilities.

All centers were contacted and requested to review their aircraft observational program for the study team. The user centers were requested to provide a 3-year program history and a 3-year requirements projection. The history and projections were to include:

- program objectives
- management approach and organizational structure
- program accomplishments
- resources, history and projections in terms of man year equivalents, total dollars, and aircraft experiments

In accomplishing the program review, center visits were also made to JPL and Wallops. Detailed program presentations were made to the committee by LaRC, LeRC, NSTL, and GSFC personnel. Three centers indicated that they were not involved in the aircraft observational program. DFRC indicated no participation, KSC involvement had been very minor, and they indicated that their small effort would not continue. MSFC indicated that they had been directed to terminate their minor activity in this area.

Once the information was acquired, the analysis of the data and information obtained first took place in several general team sessions. It soon became apparent that special subcommittees would be required to address several crucial areas. Structural subtask teams were formed to address three issues:

- future requirements definition and validation
- consolidation
- policy issues

The analysis of all the data and information was concluded prior to the status report presentation on November 7, 1977, and preliminary conclusions and recommendations had been reached at that time. Completion of the subtask team effort and verification of the detailed data were significantly more difficult and time-consuming than first estimated, but the final results required no substantial change to the preliminary conclusions and recommendations.

OBSERVATIONAL AIRCRAFT COMPLEMENT

The NASA aircraft fleet totals 102 aircraft for all uses, and the fleet logged 22 658 flight hours in FY 1977. A total of 24 NASA aircraft were utilized as observational platforms and in zero "G" work in FY 77 and flew a total of 5108 flight hours. Aircraft used as observational platforms fall into two major categories: (1) Those aircraft whose principal use is for observational purposes; and (2) those aircraft which are used to support a wide variety of program needs in addition to supporting the observational program. Figure 4 is an overview of the aircraft used to support the observational programs. The observational program utilized 14 principal aircraft that logged 4315 flight hours. The total R&D cost for the operation of these aircraft was $8714 K including $1241 K of reimbursable funds. The operation required 141 man years of support - 50 civil servants and 91 support service contractors.

Ten field center program support aircraft were also used in the observational programs. These aircraft logged a total 1959 hours of which 793 hours were in support of the observational programs. The aircraft operation R&D cost was $491 K and required an estimated 21 man years of effort (12 civil servants and 9 support service contractors). Figures 5 and 6 are a list of the principal aircraft and the other field center aircraft, respectively. Also shown are the flight hours for each aircraft and the Headquarters program offices that supported each aircraft activity.

The KC-135 is not an observational platform, per se, but it is used for Zero "G" work and is supported by all four Headquarters program offices. This aircraft, therefore, was not included in the observational aircraft studies but is included in the data base.

PROGRAM REVIEWS

OSS Airborne Science Program (UPN 352)

The OSS airborne science program supports five areas of scientific investigation. Figure 7 shows the areas of investigation and the aircraft that are used to support those

GENERAL OBSERVATIONAL AIRCRAFT OVERVIEW

FY 77

	PRINCIPAL OBSERVATIONAL AIRCRAFT	FIELD CENTER PROGRAM SUPPORT AIRCRAFT	TOTALS
NUMBER OF AIRCRAFT	14	10	24
TOTAL HOURS FLOWN	4315	*793/1959	5108
AIRCRAFT OPERATIONS R&D COST	** 8714 K	491 K	** 9205 K
AIRCRAFT OPERATIONS MANPOWER	CS - 50 SSC - 91	CS-12 (EST.) SSC-9 (EST.)	CS-62 SSC-100

* $\frac{\text{OBSERVATIONAL FLIGHT HOURS}}{\text{TOTAL FLIGHT HOURS}}$

** INCLUDES 1241 K REIMBURSABLE

Figure 4

PRINCIPAL AIRCRAFT SUPPORTING APPLICATIONS AND SCIENCE

		FY 77 FLIGHT HOURS	PROGRAM OFFICE SUPPORT
	ARC		
	LEAR 24	424	S
	C-141	669	S
(2)	U-2	711	E,S
	CV-990	403	E,R,S
	JSC		
	C-130	283	E
	BELL 206	229	E
	BELL 47	142	E
	P-3	518	E
	KC-135	137	E,S,R,M
	WB-57	289	E
	WB-57 (ERDA)	304	E
	LERC		
	OV-1	28	E
	NSTL		
	E-18	178	E
TOTALS	14 A/C	4,315	

Figure 5

OTHER AIRCRAFT SUPPORTING APPLICATIONS AND SCIENCE

		* FY 77 FLIGHT HOURS	PROGRAM OFFICE SUPPORT
	ARC		
	LEAR 23	152/206	S,R
	CESSNA 402	150/162	E
	LERC		
	C-47	115/245	E
	F-106	146/152	E
	WFC		
(2)	C-54	108/324	E,R
	C-45	25/76	E,R
	UH-1B	25/75	E,R
	KSC		
	C-45	60/187	E
	JPL		
	QA 80	12/532	-
TOTALS	10 A/C	793/1959	

$$^{*}\frac{\text{OBSERVATION FLIGHT HOURS}}{\text{TOTAL FLIGHT HOURS}}$$

Figure 6

OSS AIRCRAFT OBSERVATIONAL PLATFORM PROGRAM

AREAS OF INVESTIGATION	AIRCRAFT USED
O ASTROPHYSICS	C-141, LEAR 705, U-2
O SOLAR TERRESTRIAL	LEAR 705
O LUNAR AND PLANETARY	C-141, LEAR 705, U-2
O UPPER ATMOSPHERIC RESEARCH	U-2, CV-990, LEAR 705, COMMERCIAL AIRCRAFT
O LIFE SCIENCE	LEAR **701**, KC-135

Figure 7

programs. The OSS aircraft program provides the C-141 and the Lear 705, each fitted with a telescope with standard interfaces available to principal investigators. This program also supplies data recording services as part of the activity. Both aircraft are operated as flying laboratories with the principal investigator responsible for supplying instruments and mission peculiar modifications. The principal investigator also operates his experiment in flight and, in the case of the C-141, operates under the direction of a mission manager and with the assistance of an in-flight telescope technician. At the end of the flight, the principal investigator receives data on magnetic tape for his use.

OSS also makes use of OA-supported aircraft (the CV-990 and the U-2's) as a small, but integral part of their program. Until recently, OSS has not been required to support the operation of these aircraft and supplied support only to the principal investigators for mission peculiar requirements and flight experiments. The OSS program has been a level of effort program for the last 3 years and is anticipated to continue as a level of effort program in the future. The program has been funded at $3800 K and is supported by 25 civil servants and 25 support service contractors. Figure 8 shows the typical program funding distribution. The $1000 K in program grants is to principal investigators that utilize the aircraft facilities.

The program operation is shown in figure 9. The potential principal investigators respond to letters of invitation for scientific investigations issued by NASA Headquarters. The principal investigator responses to the invitations include the background for the proposed investigations and discussions of previous experiments, the proposed science, and the number of flights, and funding required. The principal investigator responses are reviewed by a peer group where they are categorized, and recommendations made for the number of flights and funding levels. Headquarters reviews the peer group recommendations and selection and approval is made. Typically, 15 to 17 principal investigator groups are accepted from the 30 to 35 groups responding. The selection of only approximately one-half the responses is not generally a reflection of the quality of the responses or needs, but rather a result of funding limitations.

Once the selection and approval process is concluded, the operation of the program is implemented by ARC. ARC provides not only overall management but also provides the mission manager, mission support and aircraft support as shown in figure 9. Since peer group standing is vital to principal investigators, the data acquired on OSS flights are generally evaluated in a timely manner and published reports are also produced in a timely fashion. This timeliness in turn provides a form of feedback through the principal investigator responses to subsequent letters of invitation.

OSS AIRCRAFT OBSERVATIONAL PLATFORM PROGRAM

(FY 77 - TYPICAL)

O IMPLEMENTED AT ARC	
O LEVEL OF EFFORT FUNDING	$3.8 M/YR
- PRINCIPAL AIRCRAFT	
C-141 OBSERVATORY - 640 FLT. HRS. LEAR 705 OBSERVATORY - 400 FLT. HRS.	
O PROGRAM FUNDING ELEMENTS	
HEADQUARTERS ASSESSMENT	$ 200 K
AIRCRAFT OPS	1250 K
AIRCRAFT INST.	850 K
TELESCOPE REPAIR & MAINT. DATA ACQUISITION & PREP.	
ARC IMS	500 K
	$2800 K
GRANTS	1000 K
TOTAL	$3800 K
O ARC MANPOWER	25.6 CS 25.0 SC 50.6 TOTAL

Figure 8

OSS PROGRAM FLOW LOGIC

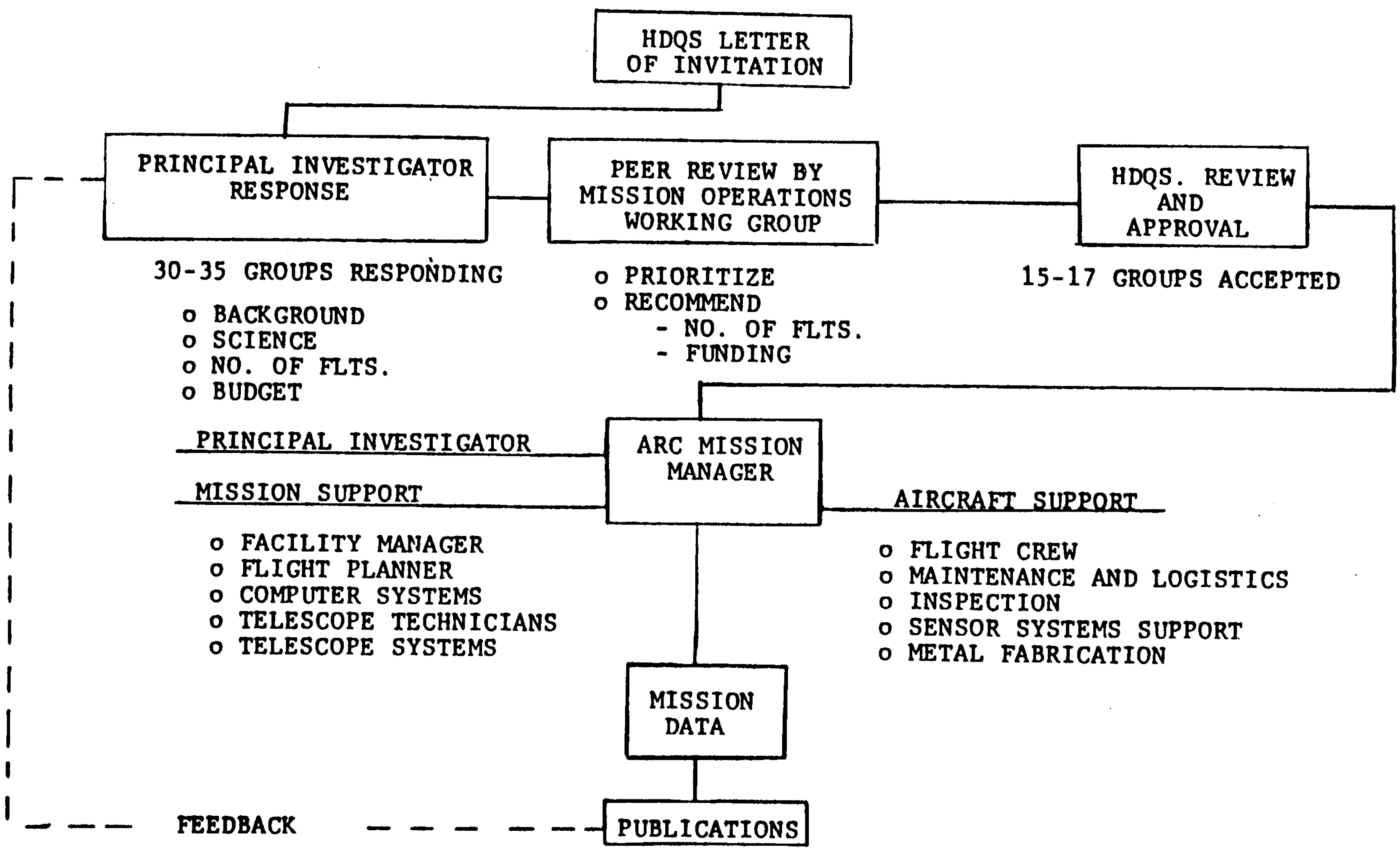

Figure 9

OA Airborne Observational Program (UPN 640)

The OA aircraft observational program is supported under UPN 640 with the title of Airborne Instrumentation Research Program (AIRP). The program supports a wide variety of investigation areas. A sample of the program areas that are supported by the AIRP is shown in figure 10. Since the program serves such a wide variety of investigation areas, it was important to understand the nature of the aircraft support required by the various discipline areas. It was possible to arrange the aircraft program support elements into seven categories:

- phenomenon observation and investigation
- in-situ measurements - stratosphere
- spaceborne sensor proof of concept and R&T
- truth data
- signal signature and algorithm development
- sensor development
- satellite underflight

In addition to understanding the nature of the aircraft support, it was also important to understand the magnitude of the support in each area. This was accomplished by examining the program history and determining the number of flight hours used by the disciplines in each support area, and, over the history span, the range of hours in each investigation area. This information is displayed in figure 11. In this chart, the high point of the bar is the historical maximum hours used in any 1 year by that support element, and the shaded portion of the bar indicates the yearly variation in that support element. As an example, in the category of signal signature and algorithm development, the historical maximum hours utilized was 1200 hours in 1 year, and the fewest hours utilized in this area was 700 hours. The data used to develop this display is estimated since the information is not collected this way. However, the estimates are sufficiently accurate to display the nature of the AIRP aircraft utilization.

The AIRP is conducted by two principal centers: ARC and JSC. The nature of the AIRP is significantly different from the OSS observational platform program, in that it focuses on earth viewing remote sensing applications. Also, the program at the two AIRP centers differs in content, aircraft type, philosophy of operation, and organizational structure. At ARC the AIRP program is highly projectized with some project support supplied by a matrix discipline organization. ARC is also the OA lead center for the AIRP and, as such, the Application Aircraft and Future Programs Office

OA AIRCRAFT OBSERVATIONAL PLATFORM PROGRAM

AREAS OF INVESTIGATION

- O WEATHER AND CLIMATE
  - SEVERE STORMS
  - CLIMATE RESEARCH
  - METEOROLOGICAL PROCESSES
- O EARTH RESOURCES
  - AGRICULTURE
  - GEOLOGY
  - HEAT CAPACITY MAPPING
- O ENVIRONMENTAL QUALITY
  - WATER
  - TROPOSPHERE
  - STRATOSPHERE
- O OCEAN DYNAMICS
  - ICE IMAGING
  - SEA STATE
  - SURFACE WIND SPEED
  - WAVE MOTIONS
- O SUPPORT TO SCIENCE PROGRAM

Figure 10

TYPICAL YEARLY AIRCRAFT OBSERVATIONAL PLATFORM UTILIZATION

FY 75 - 77

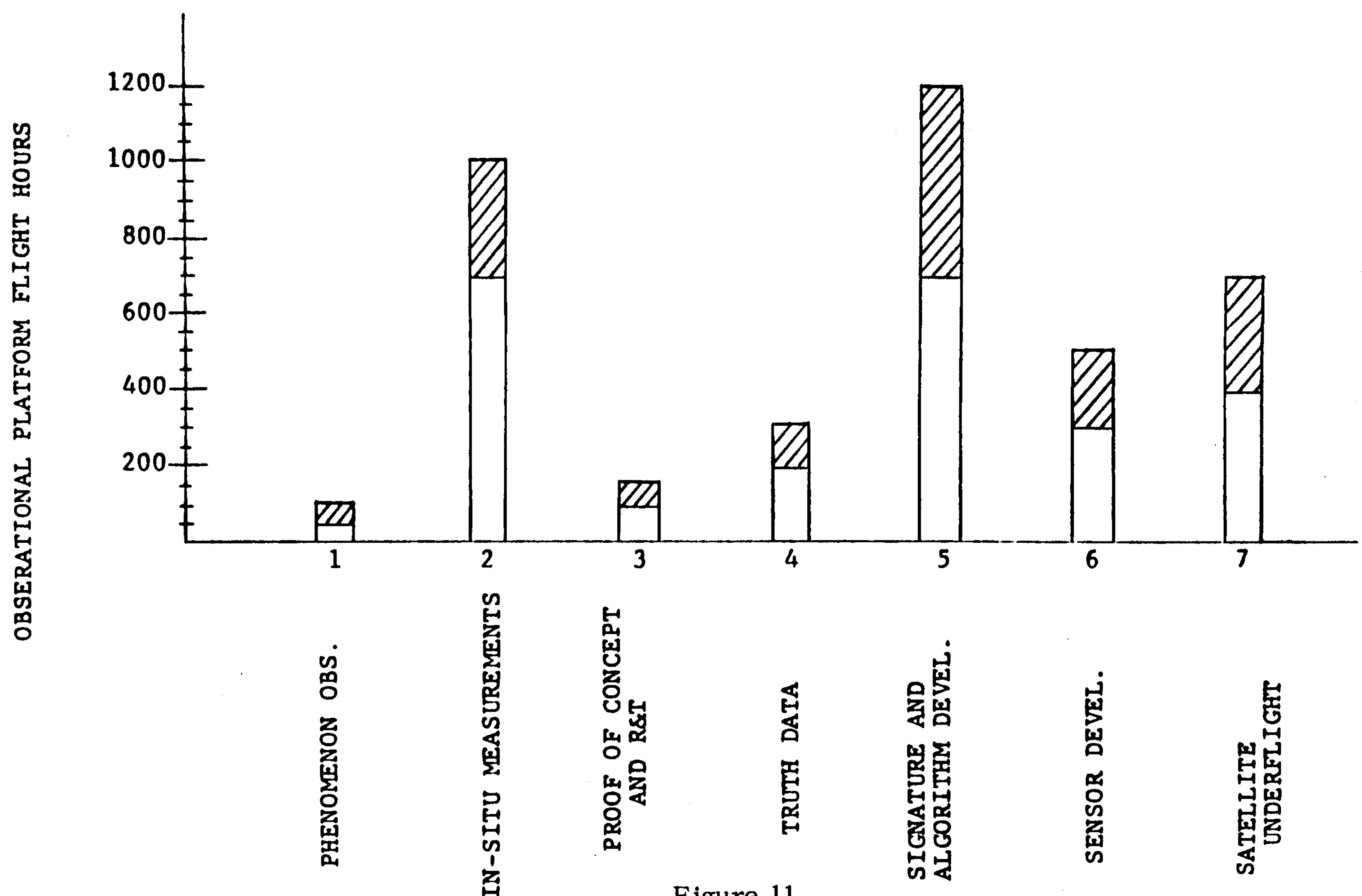

Figure 11

(AAFPO) provides overall support for the development of annual program plans based on incoming requirements. Aircraft operations are staged principally from Moffett Field, an operational Navy field adjacent to ARC. The OA aircraft operated by ARC are a CV-990 medium altitude jet and two high altitude U-2's.

The CV-990 is operated much in the same manner as the C-141 in the OSS program in that the aircraft is essentially a flying laboratory with the principal investigator responsible for providing the investigation instruments, mission peculiar modifications, and operating the experiment in flight. The U-2's are one person aircraft which are operated as general purpose instrument platforms with the principal investigator participating in the mission planning and providing the instruments, mission peculiar modifications, data reduction and analysis.

In FY 77, the AIRP program at JSC utilized the C-130, 2 WB-57F's, (one WB-57 is totally ERDA reimbursed) 2 helicopters and a P-3A. In FY 78, the P-3A and one helicopter were removed from the aircraft complement. The program is managed by the Earth Resources Program Office with support from the JSC line organizations through a matrix management structure. The JSC aircraft are operated principally as data acquisition platforms with a fixed sensor complement carried on each flight. The principal investigator is involved in mission planning, flight planning and ground data acquisition. Modifications currently being made to the C-130 will allow on-board principal investigator participation. This information is summarized in figure 12. The JSC program is also characterized by a major effort in aircraft instrumentation including sensor maintenance, modification and operation, and data processing. JSC operates out of Ellington AFB which is a short distance from the Center.

The AIRP program has changed considerably since its inception. Initially, its primary function was to support the earth observations program and, with time, has evolved to support all applications disciplines and a portion of the OSS science program. The AIRP program has also been characterized by a decreasing budget accompanied by changes in policy, size of the program and its content. Funding reductions have also limited the extent of support provided other Program offices. The changing nature of the AIRP program and the different character of the ARC and JSC portions can best be seen through a display of the total resources expended by the program and distribution of those resources at the two centers (fig. 13). The total resource level of the program decreased from $14.3 million and 526 man years in FY 75 to $9.1 million and 273 man years in FY 78. The funding level for FY 78 was an OA-directed decrease. This decrease in funding reduced by half the total his-

AIRBORNE INSTRUMENTATION RESEARCH PROGRAM

CHARACTER OF PROGRAM

ARC

CV-990

MINIMAL FIXED SENSOR COMPLEMENT (BORESIGHT CAMERA, RADIOMETER)
MAIN THRUST - SENSOR TEST AND DEVELOPMENT, SCIENCE, PHENOMENA INVESTIGATION
AIRCRAFT IS FLYING LABORATORY
PRINCIPAL INVESTIGATOR:

- SUPPLIES INSTRUMENTS
- PROVIDES MISSION PECULIAR MODIFICATIONS
- OPERATES EXPERIMENTS IN FLIGHT

U-2

MINIMAL FIXED PHOTOGRAPHIC SENSOR COMPLEMENT
MAIN THRUST - GENERAL PURPOSE INSTRUMENT PLATFORM
PRINCIPAL INVESTIGATOR:

- SUPPLIES INSTRUMENTS
- PROVIDES MISSION PECULIAR MODIFICATIONS

DATA ACQUIRED AND SUPPLIED TO PRINCIPAL INVESTIGATOR

JSC

C-130, WB-57, P-3

FIXED SENSOR COMPLEMENT FOR EACH FLIGHT
MAIN THRUST - DATA ACQUISITION
NO DIRECT PRINCIPAL INVESTIGATOR INVOLVEMENT
DATA ACQUIRED AND SUPPLIED TO PRINCIPAL INVESTIGATOR

Figure 12

OA AIRCRAFT INSTRUMENTATION RESEARCH PROGRAM (AIRP)

RESOURCES SUMMARY

O PRINCIPAL AIRCRAFT (FY 77)

JSC	ARC
WB-57F (2)*	U-2 (2)
NC-130B	CV-990
P-3A	
2 HELICOPTERS	

O PROGRAM FUNDING (MILLIONS)

	FY 75	FY 76	FY 77	FY 78
ARC	4.2	5.1	5.2	2.9
JSC	10.1	8.0	7.6	6.2
TOTAL	14.3	13.1	12.8	9.1

O MANPOWER

		FY 75	FY 76	FY 77	FY 78
ARC -	CS	19	23	24	24
	SSC	52	57	59	51
		71	80	83	75
JSC -	CS	141	104	97	59
	SSC	314	210	197	139
		455	314	294	198
	TOTAL	526	394	377	273

*ONE WB-57F TOTALLY REIMBURSED BY ERDA.

Figure 13

torical number of flight hours being supported at ARC, reduced the manpower efforts at JSC and resulted in the elimination of the P-3A and one helicopter from the JSC aircraft complement and a reduction in sensor complement.

The distribution of manpower and funding between JSC and ARC indicates the difference in the nature and operation of the programs at those centers. The ARC funding and manpower level has been relatively constant, with the exception of FY 78. The JSC program has been funded at significantly higher levels and utilized a much higher manpower level of effort. Both the funding level and manpower level at JSC have decreased since FY 75. These changes have been accommodated by a consolidation of the data acquisition and preparation efforts and a change in the nature of the aircraft instrumentation effort. From-the-ground-up development of sensors has been deleted from the program. However, modifications of existing sensors are carried out. Such modifications, carried out under other programs, are often characterized as sensor development.

The difference in the nature of the ARC and JSC AIRP program can be seen in a further breakdown of the resources shown in figure 14. The difference in aircraft operations resources shown in figure 14 are due to the U-2 operations. The major programmatic difference between ARC and JSC is indicated in the order of magnitude funding difference in aircraft instrumentation. As stated previously, the JSC program involves a major effort in sensor operation, maintenance, modification, and general purpose electronic data processing. The approximate two-to-one difference in funding of data acquisition/preparation is due to processing of electronic data at JSC.

There are no electronic sensors at ARC nor related data processing activities sponsored by the AIRP. The AIRP U-2 sensor work at ARC is limited to camera systems and film processing. The CV-990 provides on-board data recording for the principal investigator, however, he processes his own data after the mission. IMS levels are reasonably consistent with the civil servant manpower levels. It was not possible to compare the manpower levels in these categories since they are not collected by JSC in this manner.

The OA aircraft program operates in a fashion similar to the OSS program, and the OA program flow is shown in figure 15. The AAFPO at ARC issues a flight request call and collects the user center responses. In the OSS program, these functions are carried out by the Headquarters program office. The center responses are simultaneously sent to OA discipline lead centers for technical review and to the aircraft project centers for flight operations requirements review. When these reviews are completed, a meeting chaired by the AAFPO is held between the discipline lead centers and the aircraft project centers where their individual reviews are integrated

OA AIRBORNE INSTRUMENTATION RESEARCH PROGRAM

FY 75 - 77

	JSC			ARC		
	FY			FY		
O PROGRAM FUNDING	75	76	77	75	76	77
AIRCRAFT OPERATIONS	2690	2100	2250	2380	3890	3900
AIRCRAFT INSTRUMENTATION	3400	2820	3230	250	260	275
DATA ACQUISITION/PREPARATION	2720	1700	1100	1270	670	680
IMS	1310	1340	1020	300	330	345
TOTAL	10,120	7960	7600	4200	5150	5200
O MANPOWER - CS/SSC						
AIRCRAFT OPERATIONS	NOT COLLECTED THIS WAY			16/22	19/28	20/29
AIRCRAFT INSTRUMENTATION				0/7	1/8	1/8
DATA ACQUISITION/PREPARATION				2/12	2/14	2/14
IMS (HANDS OFF DIRECT SUPPORT				1/7	1/7	1/8
TOTAL	141/314	104/210	97/197	19/52	23/57	24/59

Figure 14

OA PROGRAM FLOW LOGIC

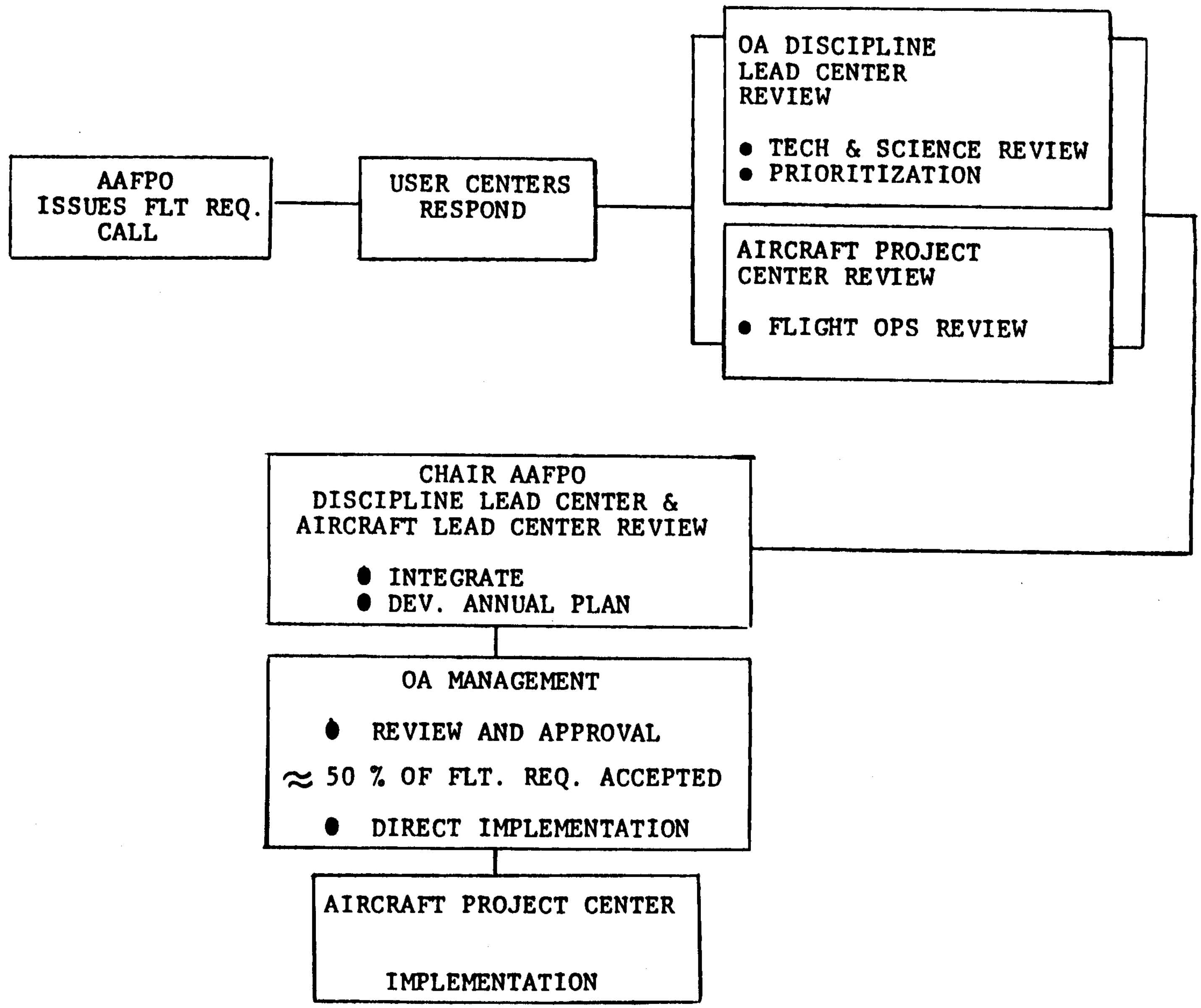

Figure 15

and the annual operating plan is developed. This plan is sent to OA management for review and approval. Approximately 50 percent of the flight requests are accepted. OA management then directs the implementation of the annual plan which is executed by the aircraft project centers. Feedback is provided by discipline users at annual RTOP reviews. However, no complete review of the research output of the aircraft program is conducted.

Observational Aircraft Reimbursable Activity

The OA observational aircraft are engaged in supporting a number of governmental agencies due to the unique capability of these aircraft. The Review Team requested that a brief review of this activity be made by each center, and a summary of that activity for FY 77 is shown in figure 16. The summary chart shows that a wide variety of government agencies utilize NASA aircraft capability in varying degrees. In addition to the cost of the reimbursable effort, the Review Team requested a copy of the agreements that existed between NASA and the user agencies. These agreements spanned the spectrum from a formal NASA Headquarters to ERDA Headquarters agreement for a dedicated aircraft (WB-57F at JSC) to a letter documenting an agreement arrived at via a phone conversation. In addition to the direct reimbursable flights, a number of cooperative programs with EPA and NOAA take advantage of the NASA aircraft observational capability. And, although it receives no reimbursable funds from these programs, the cooperative nature brings to NASA data and information (often ground or sea truth) that could not be obtained without the expenditure of additional resources. Arrangements for reimbursable activity vary considerably; however, these arrangements seem to be working well with no obvious difficulties. Policies governing interagency support missions are issued by OA annually in a call letter to the user community. The letter includes aircraft charges for planning purposes.

OA/OSS Observational Program Summary

The following summary illustrates the magnitude of the FY 77 and 78 OA/OSS observational program.

	FY 77			FY 78
	OA	OSS	Totals	Totals
Funding	12 800 K	3 800 K	16 600 K	12 900 K*
Manpower				
CS	121	25	146	108
SSC	256	25	281	215
	377	50	427	323

*AIRP funding reduction only.

FY 77 REIMBURSABLES FOR AIRCRAFT OPERATIONS

Aircraft	Amount	Agency
WB-57 (ERDA)	469K	ERDA (A/C Dedicated to Project Airstream)
WB-57 (NASA)	66K	DOI
	7K	USGS
	68K	DOA
	7K	COE
	148K	
CV-990	140K	ESA
	50K	NOAA
	190K	
Lear 23	25K	Air Force
	9K	Washington State University
	17K	FAA
	51K	
U-2	172K	ARPA
	43K	USDI
	10K	USCG
	40K	EPA
	24K	IBWC
	3K	Department of Navy
	25K	USDA
	3K	FDAA
	7K	Fresno County
	13K	USGS
	340K	
C-130/P-3	19K	EPA
	18K	COE
	1K	NOAA
	38K	
C-54	5K	NOAA
TOTAL	1241K	

Figure 16

The reimbursable effort is not quite 10 percent of the total funding level, and all manpower used in the reimbursable activity is within the indicated manpower levels.

Field Center Program Support Aircraft Utilization

For the purposes of this report, field center program support aircraft are defined as aircraft stationed at, and operated by, the field centers to support center Research and Technology programs. These aircraft are used primarily to support OAST space and aero technology and OSS life science programs.

Center program support aircraft are also used in varying degrees to support both science and applications programs. When these aircraft are used for OA and OSS programs, the operations funding comes directly from the discipline offices as needed to support program goals. OA programs that utilize these aircraft are earth resources, environmental quality, weather and climate, ocean dynamics, and civil systems. OSS programs that are supported are upper atmospheric research and life science. These aircraft are used quite often to support R&T program requirements that are difficult or impractical to support within the general purpose observational program. One such requirement is for R&T programs that require the planned observation of phenomenon that cannot be scheduled. Examples are red tide observation in a given test area where repeated observations are required but the time of the event cannot be predicted or scheduled. Another example is the Great Lakes river run off program where separate observations of major river run off is required during discharge after major rainfalls or storms. The ability to predict the time of such events is very poor at best.

Additional efforts that are supported by the observational aircraft include disaster assistance/targets of opportunity/good neighbor activities. A survey was made, as part of the team review, of the past 3-year history of this activity. Surprisingly, this is a very low level activity averaging in the order of four to six flights per year for a total of 30 to 80 hours. The consideration, of course, is the fact that these opportunities are highly visible. There are no consistent NASA policies concerning this area, and the problem is addressed in dramatically different ways at the various centers. It is clear that a very simple, straightforward policy and procedure needs to be established by Headquarters to address this issue.

Figure 17 shows the field center program support aircraft used for OSS and OA observational programs in FY 77. A total of ten aircraft were utilized at five centers. These aircraft flew almost 2000 hours with almost 800 hours, or 40 percent of those hours, supporting OA and OSS programs. The cost to support these observational

PROGRAM SUPPORT AIRCRAFT

FY 77 - TYPICAL

		OBSERVATIONAL FLIGHT HOURS / TOTAL FLIGHT HOURS	OBSERVATIONAL FLIGHT COSTS ($K) / TOTAL FLIGHT COSTS ($K)
ARC			
	LEAR 23	152/206	118/160
	CESSNA 402	150/162	47/51
JPL			
	QA 80	12/532	0/0 (R+PM FUNDED)
KSC			
	C-45	60/187	12/35
LERC			
	C-47	115/245	32/68
	F-106	146/152	146/152
WFC			
(2)	C-54	108/324	106/317
	C-45	25/76	15/44
	UH-1B	25/75	15/46
TOTAL	10 A/C	793/1959	491/873

Figure 17

flights was about $500 K of a total of slightly under $900 K. The two centers, ARC and LeRC, that show a large percentage of the total flight hours devoted to observational programs also have significant OA programs and this level of aircraft support can be expected. At KSC aircraft support will be phased out in the next year or two. The JPL aircraft is an administrative aircraft that has been used to support sensor development.

ANTICIPATED NASA OBSERVATIONAL AIRCRAFT NEEDS

The development and validation of future aircraft observation needs proved to be a difficult task to perform with great accuracy. In order to acquire the most reliable projections of future needs, the following procedure was followed:

- Obtained 3-year history from 4 sources
  - OA/OSS program offices
  - Lead centers
  - User centers
  - Headquarters aircraft office
- Obtained 3-year requirements projections from 3 sources
  - OA/OSS program offices
  - Lead centers
  - User centers
- Examined use history and projected requirements
- Examined OA and OSS procedures for experiment flight acceptance
- Applied historical program factors, where necessary, to arrive at anticipated needs

Based upon the above analysis, an estimate of future requirements for OSS, OA, and field center support aircraft in support of observational aircraft needs was made.

OSS Program

The OSS program is oversubscribed by at least a factor of two. The current level of effort utilizes significantly less than the maximum capability of the two observational aircraft (C-141 and Lear 705). It also appears that good science programs that could be supported by the aircraft are not being accomplished due to manpower and funding limitations. The utilization of these aircraft could be easily increased by 50 to 100 percent if the resources were made available.

OA Program

Currently, approximately 50 percent of the flight requests are being implemented. Approximately 20 percent of the flight requests are rejected due to poor justification, unclear project plans, or insufficient project funding. The additional 20 to 30 percent reductions are due to combining investigations for fewer flights. Under this process, the valid flight requests must be fitted within the capability of the AIRP in terms of available resources and flying hours. While most of the top priority requests are satisfied, much good work, possibly as much as 30 percent of the valid requests, does not get supported.

In the medium altitude area, the C-130 is oversubscribed while the CV-990 is underutilized due to funding limitations. These aircraft appear to be able to satisfy medium altitude observational needs through the late 1980's if resources are provided and if policy positions stabilize aircraft availability and aircraft user charges.

At least the current level of both high altitude flight activity (historically, 1200 to 1400 hr/yr including hours for ERDA) and performance capabilities will be required for the foreseeable future. The high altitude fleet includes aircraft that are no longer major operational aircraft. The WB-57F's are currently used only by NASA, with Air Force high altitude observational requirements being met with other aircraft. The WB-57F's have not presented maintenance or parts problems since parts can be obtained from a number of the aircraft in storage at Davis Monthan AFB, Arizona and logistics support is provided by the Warner Robins Air Logistics Center, Georgia. However, it can be anticipated that the ability to maintain these aircraft in flight-certified condition may become difficult and potentially costly in the future, if the Air Force were to withdraw its support. Both the U-2's and the WB-57F's are somewhat under-utilized primarily due to flight hour funding limitations.

Field Center Support Aircraft

There was no evidence available from users or from the supporting program offices that indicated any significant change in the flight hour requirements for these aircraft is anticipated.

There is also no indication that the use pattern will change in the near future. The field centers respond to programmatic needs by the most effective method available. The nature of the programs supported by the field center aircraft require flexibility in flight schedules that would be difficult or impossible to support by the principal operational aircraft.

CONSOLIDATION

In considering the desirability of consolidation, two approaches were examined: geographical consolidation and fleet-type consolidation. Consolidation needs to be considered to determine if NASA observational aircraft needs can be met with an economy of resources. In considering geographical consolidation, moving all principal aircraft to either JSC or ARC was examined as an example of potential operational economies. The aircraft selected as consolidation candidates are shown in the table below.

Aircraft	NASA No.	Center
U-2	708	ARC
U-2	709	ARC
C-141	714	ARC
CV-990	712	ARC
Lear 24	705	ARC
WB-57F	926	JSC
WB-57F (ERDA reimburs.)	928	JSC
C-130	929	JSC

R&D costs for recurring operations were identified in three categories - aircraft costs, sensor and instrument costs, and data management costs. Recurring C of F costs were determined to be nonexistent. R&PM costs would remain unchanged after consolidation. The committee assumed that <u>civil service</u> manpower ceilings at the centers would not change.

Nonrecurring costs were treated in much the same way as recurring costs. R&PM costs and C of F costs were considered along with R&D costs, because of their potential impact on the total cost to NASA of any consolidation activity.

The data were analyzed by reviewing center data at a primary functional element level, and comparing these projections to present-day operations costs. These estimates were then reviewed by the committee to ensure comparable levels of flight activity and to ensure comparability of baseline data and ground rules between the two centers. The values represent only a committee best estimate and are not necessarily center positions on consolidation.

As a means of determining budget impact, the total nonrecurring cost to NASA for the aircraft program only (all fund sources) was compared with the estimated recurring cost savings realized from consolidation at each center to arrive at a breakeven point in time; i.e., that point in time when the cumulative discounted cash flow of savings would equal thte initial nonrecurring investment. The earlier this break-even point is reached, the more feasible the consolidation appears in terms of future cost savings to the agency.

Non-Budgetary Criteria were itemized. Their impact on the decision process was not quantified in many instances because of the subjective nature of their economic value. However, many were ground-ruled as constants so as to allow a baseline comparison of the cost factors. The important point that should not be overlooked when reviewing this study is that it represents only one consolidation scenario that is based on certain ground rules which may either radically constrain or overstate the estimated savings of consolidation.

The estimated recurring cost for consolidated operation is roughly equal at either Center. The differences in nonrecurring costs are minimal, with the exception of the cost to relocate the JSC AIRP data support function at ARC. The total nonrecurring cost varies from 1300 K for consolidation at JSC to 2100 K for consolidation at ARC. Based on this study, the potential savings in operations cost that could be realized by consolidation is in the order of $2000 K to $2500 K; therefore, only a 1-year payback time would be required if these savings are truly attainable.

Based on the study groundrules, some inferences can be drawn and some findings can be summarized. JSC and ARC R&D recurring costs are approximately equal. Similarly, the civil service manpower required by each center is approximately equal. Differences in the in-house support contractor man-years between the Ames and Johnson consolidation figures represent the different modes of contractor operations for air frame and engine maintenance. ARC contracts out-of-house most of this work, while JSC uses in-house support contractors. Thus, the contractor man-years do not reflect a different level of work, but only highlight different methods of doing business. Likewise, this applies to sensor operations.

The magnitude of the nonrecurring costs are comparable, except for the one-time cost to relocate the JSC AIRP data support at ARC. The committee judged that it is reasonable to expect a 1-year implementation time during which the transfer of aircraft, equipment, data processing capability and sensor support can be accomplished. The modifications and additions to existing facilities also could be accomplished within the 1-year implementation period. During this 1 year time span, the aircraft would continue to operate out of their present facilities and would transfer as their flight schedules permitted.

Before making any assumptions about the benefits of consolidation, a few caveats need emphasizing. First, this exercise used only one set of aircraft and two centers in determining recurring and nonrecurring costs. Many aircraft and center combinations are possible which may be more or less "efficient" in terms of cost savings. The data indicates that the cost to fly the airframes will not vary much for a given level of activity regardless of where the aircraft are located.

The largest potential area in which NASA could realize economies of operation lies in the nonaircraft supporting functions: sensor and data support. However, these supporting functions are a part of each center's R&D technical base, and to a degree are charges applied to the aircraft program as well as to other R&D programs by an allocation process. As such, this effort may not be easily terminated at, or transferred from, the respective centers without impacting the allocation to other ongoing or planned for R&D activities. Reducing the aircraft's data or sensor processing support at one center may just shift all or part of that same burden over to other R&D programs. In short, significant savings to NASA may not be attainable.

In addition to fiscal aspects of consolidation, intangible and/or unquantifiable factors also need to be considered since they may have significant programmatic impact. Following is a list of such factors that should be considered before any consolidation decision is finalized. It is not necessarily complete.

- Morale at centers due to impact of any transfer of civil service personnel or adjustments to center manpower ceilings.
- Impact on roles and missions assignments of respective centers.
- Down time and diseconomies occurring while consolidation actually takes place.
- Outlook for Ellington Air Force tenancy costs.
- Availability of a full complement of U-2 pilots in the JSC area.
- Community impacts of additional aircraft.
- Increased air traffic density, especially at Ames.
- Weather and cloud cover restrictions on flight activity.
- Future aircraft buys coupled with fleet additions or retirements might lead to increased economies in any consolidation exercise.

The intangibles of this (or any) consolidation cannot be ignored out of hand. They must be reviewed in detail for their possible impact on this consolidation or on other agency activities or policies. The ground rules and assumptions that were used in this exercise must also be reviewed in light of their applicability to other scenarios, or to changes in NASA policy.

Additionally, these numbers do in fact only represent committee work. Although the numbers were generated through use of a grass roots approach at each center, there are no endorsements by center management of any of the consolidated operating cost estimates and no guarantee that the nonrecurring cost estimates could not exceed the ranges presented.

Since the potential savings due to geographical consolidation may not be realized because of the nature of these expenditures, and due to the fact that the intangible factors may have significant negative programmatic effects, geographical consolidation is not recommended at this time.

An alternate to geographical consolidation is fleet consolidation by type and number of aircraft.

As stated previously, at least the current level of both high altitude flight activity (historically 1200 to 1400 hr/yr including hours for ERDA) and performance capabilities will be required for the foreseeable future. The existing fleet (2 U-2's, 1 NASA WB-57F, 1 ERDA WB-57F) can fly up to a total of about 2000 hours per year. Since the high altitude fleet is underutilized, the option of fleet consolidation should be considered. It should be noted that the current fleet provides a mix of large payloads, altitude possibilities and ranges for observational tasks. For example, the WB-57F cannot fly as high as the U-2, while the U-2 cannot handle large payloads. Both aircraft are presently needed because of their unique performance capabilities.

In the development of consolidation scenarios, performance requirements should be carefully evaluated. Given the long term need, airframe update should also be considered. Current USAF plans to acquire the ER-2, an aircraft with considerably expanded performance over both the U-2 and the WB-57F, offer NASA an opportunity to update airframes, meet current performance capabilities, and, in fact, offer expanded performance capabilities with fewer aircraft. Additional options, costs and implementation scenarios should also be considered.

However, any commitment to upgrading must be substantiated by firm programmatic needs and the evaluation of the value of the extended capability afforded by updated aircraft.

In considering fleet upgrading, several additional factors need to be addressed. It is probably expedient to confirm, by a high level NASA Headquarters executive, that, in fact, a fleet of ER-2 aircraft will exist and be supported by the Air Force for an extended period of time. The firmness of the unit price and pricing ground rules should also be confirmed at a high level. Along with the possible updating of the high altitude aircraft, consolidation at the Center that operates the aircraft of the instrumentation and data reduction function for the high altitude aircraft should be considered.

Several additional items need to be addressed in order to complete the consolidation considerations. Although helicopters were not specifically addressed in this summary and are not a large part of the aircraft observational program, there are important savings that can be accrued in this area. The two helicopters stationed at JSC, and used for earth observation, cost a total of approximately $235 K to operate for 371 hours in FY 77. In FY 78, one helicopter was eliminated from the program, and the one remaining helicopter supports a joint USA/USSR program.

Helicopters are currently being leased and/or rented in an essentially on-call basis by other NASA R&T programs for between $120 and $130 per hour. If the earth resources program needs could be met by leased or rented helicopters, operational economies could be realized.

OBSERVATIONS/FINDINGS/RECOMMENDATIONS

Observations/Findings

- Observational aircraft support a wide variety of research programs in all of the program offices.
- All Centers presenting program overviews consider the observational aircraft as critical to their programs.
- In many programs, observational aircraft are perceived as a necessary link between ground based research and technology and space flight.
- Observational aircraft users desire/require increased capability at both medium and high altitudes.
- The need for a healthy, vigorous observational aircraft program is projected to continue throughout the shuttle era as a cost effective step to provide:
  - sensor development
  - algorithm development and signature understanding
  - satellite underflights
- The demand for observational aircraft may increase or decrease as the shuttle launch rate increases.
- OA-supported observational aircraft effort has been reduced in scope and changed in character over the past several years.
- Observational aircraft efforts at ARC and JSC are significantly different in character.
- The natures of the OSS and OA programs are significantly different.

  OSS effort
  - Easily and clearly focused
  - Simple implementation approach
  - Funded at level of effort

OA effort

- Scope is complex and difficult
- Supports diverse disciplines and needs
- Funding level continuously decreasing

- Inconsistencies exist in the implementation of target-of-opportunity/disaster/good neighbor efforts
- Reimbursable charge allocation policies are, in some cases, not developed early enough to permit users to budget for required funds.
- Some of the flight equipment is of a type no longer used operationally by anyone but NASA.
- Program support aircraft are often used to conduct planned but unschedulable flights that would be an inefficient use of principal general purpose aircraft.
- There is no Headquarters level management overview of field center program support aircraft, except for limited overview by the OA lead center.
- Some satellite underflight requirements are not identified sufficiently early to permit proper support planning.
- Policy on user charges based on aircraft funding changes leads to increasingly complicated aircraft operations problems, perhaps to the point of counter-balancing any anticipated savings.
- OA discipline advocacy for use of observational aircraft is splintered organizationally and geographically, severely hampering the advocates' effectiveness.
- There is no easy means of evaluating the total return from the OA observational aircraft use; however, interaction with the user Centers indicates a generally high rate of return on a reasonable investment.

Recommendations

- A programmatically stable observational aircraft support capability should be provided to meet NASA's and national research and technology development needs.
  - Establish the operational funding level of support (similar to ground and space laboratory activities) and define the services provided within this funding level.
  - If NASA users are to be charged, the ground rules should be applied uniformly.

- Policy positions for all observational aircraft should be developed.
  - Principal general purpose aircraft (e.g., U-2, WB-57F, C-130, CV-990)
  - Field center program support aircraft
- The observational aircraft are a National capability used broadly
  - Policies governing interagency and industrial cooperative and reimbursable programs should be reviewed.
  - Target-of-opportunity/disaster/good neighbor policy and procedures should be established and applied uniformly.
- Senior Headquarters (multi-program office) personnel should establish a process to provide periodic review (oversight) of principal observational aircraft program activities.
- A mechanism to screen requirements for all elements of the aircraft program should be established without degrading the flexibility of the Center-managed aircraft.
- Procedures used to determine the complement of standard instrumentation/sensors to be included in the program and permit periodic updates of this standard capability should be reviewed.
- Charges for sensor modifications should be applied to the discipline(s) requiring the increase or change in capability.
- The level of electronic data processing/formatting to be provided to users within fixed charges should be reviewed.
- Feedback from observational aircraft users should be focused, to provide a separable, visible source for periodic assessment of the effectiveness of aircraft utilization.
- Scoping of satellite underflight requirements should be required as a part of the satellite project plan.
- Utilization of field center program support aircraft as observational platforms should be encouraged wherever cost effective.
- Consideration should be given to retirement of helicopters supporting earth observations, and acquisition of this capability through lease or rental. (It may be beneficial to adopt this posture to all helicopter support to NASA programs that are not specifically helicopter R&T efforts.)
- Fleet consolidation of aircraft type and number should be considered.
  - Now for high altitude fleet
  - 3 to 5 years from now (after Shuttle experience) for medium altitude fleet.